International GNSS Real-Time Service – New Products for Real-Time Applications

and Integration of Multi-GNSS Signals

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IGS Key Projects

- Real-Time Pilot Project (2007 – 2012)
  - Develop, manage and maintain real-time GNSS infrastructure
    - Global GNSS tracking network, combined orbit and clock products and product distribution to users
  - Develop data formats and transmission protocols
    - IGS became a member of RTCM in 2009 (SC-104)
  - Support scientific and other applications
- → IGS Real-Time Service officially launched April 1, 2013
- Multi-GNSS Experiment (MGEX) Project
  - prepare IGS for new GNSS constellations and signals

IGS Real-Time Service

- International effort with many contributions:
  - GNSS tracking stations, data centers, analysis centers, combination centers, analysis coordination

IGS Real-Time Service

- Large global network consisting of 150+ stations
- Real-time orbits accurate at the 3-cm level; real-time clocks at the sub-ns level
  - decimetre level service (2drms)
- Compelling redundancy concept
- Open data policy
- Using open RTCM standards for both data and orbit and clock corrections.
  - IGS has been a member of RTCM since 2009
- IGS cannot execute a Service Level Agreement
  - Use at own risk

IGS Real-Time Tracking Network

150+ stations

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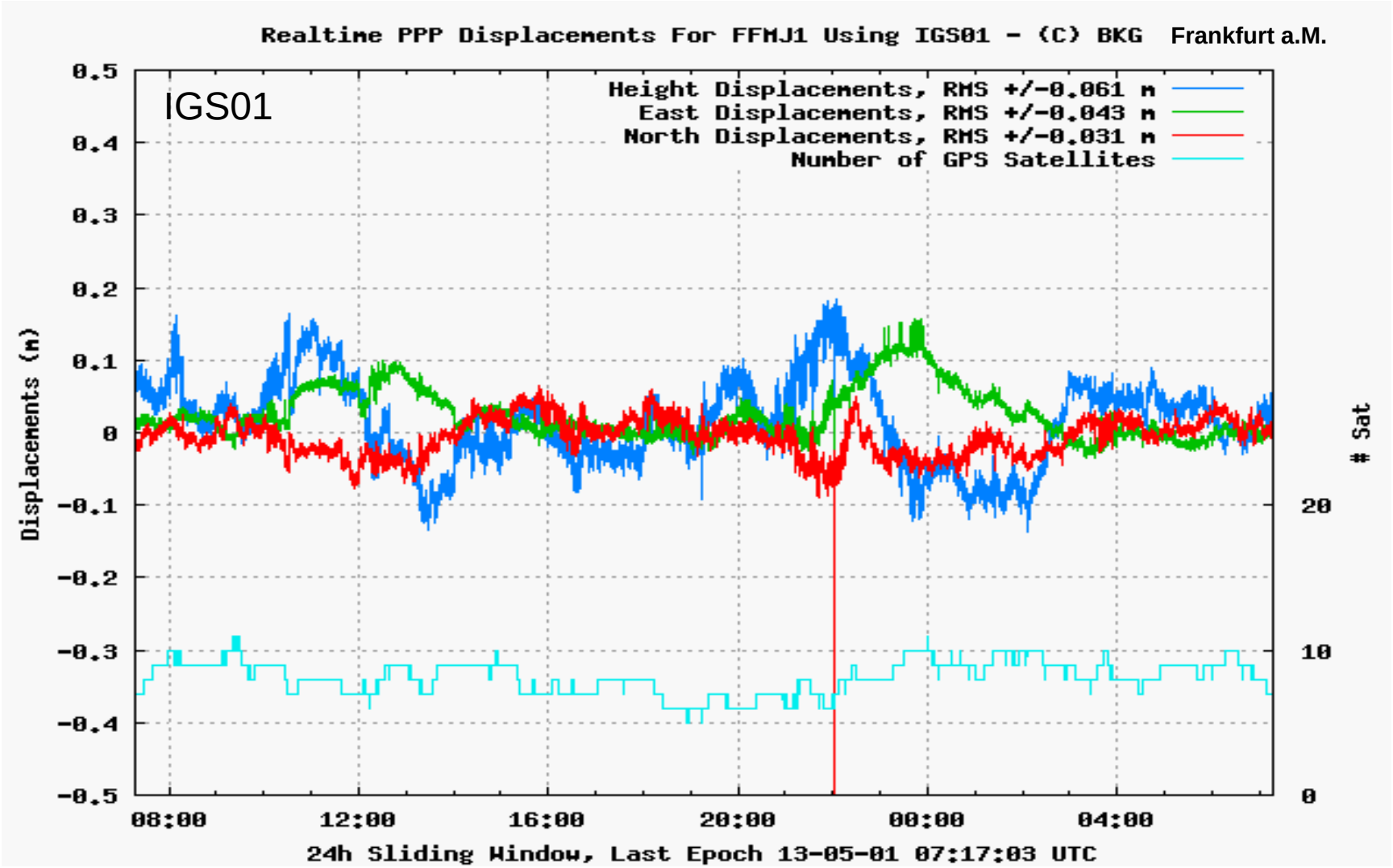
IGS RTS Products

- Initial Operational Capability (IOC), Full Operational Capability (FOC) expected later this year
  - Rapidly developing into a multi-GNSS service
- Two GPS products and one experimental GPS+GLONASS product:

IGS01/IGC01	GPS-only	orb & clk	single epoch combo	1.8 kb/s
IGS02	GPS-only	orb & clk	Kalman combo	0.6 kb/s
IGS03	GPS+GLO	orb & clk	Kalman combo	0.8 kb/s

- Broadcast stream GPS+GLONASS+Gal (RTCM3EPH)
- Reference is ITRF2008
- Stream access via BKG NTRIP Client (BNC) or RTKLIB

IGS RTS Product Performance



IGS RTS Applications


APF

- Innovative support for public benefit applications
- Enables real-time precise point positioning (PPP) at global scales for scientific and hazard detection applications, weather and space weather forecast, multi constellation performance monitoring
- Rapidly detecting, locating, and characterizing hazardous events such as earthquakes and tsunamis
- Contributing to GGOS Theme 2 “Natural Hazards”

IGS RTS Users

- 80 user registrations within days of launch
- 142 user registrations by 22 April, from 38 countries

By Organization Type	
Engineering Services/Consulting	25
Academic	23
GNSS Equipment/Software	15
Aerospace	4
Government Geological/Geophysical	3
Government Geodetic/Mapping	2
Positioning Services	2
Telecommunications	2
Other	2
Civil Aviation Authority	1
Government Meterology	1
Military	0

By Country	
USA	14
Canada	7
Australia	6
Brazil	5
Japan	5
Russia	5
Italy	3
Malaysia	3
UK	3
Bosnia Herzegovina	2
Bulgaria	2
China	2
France	2
Germany	2
Iran	2
Republic of Korea	2
Romania	2
Saudi Arabia	2
Spain	2
Austria	1
Egypt	1
Finland	1
Greece	1
Indonesia	1
Kenya	1
Philippines	1
Ukraine	1
Uruguay	1

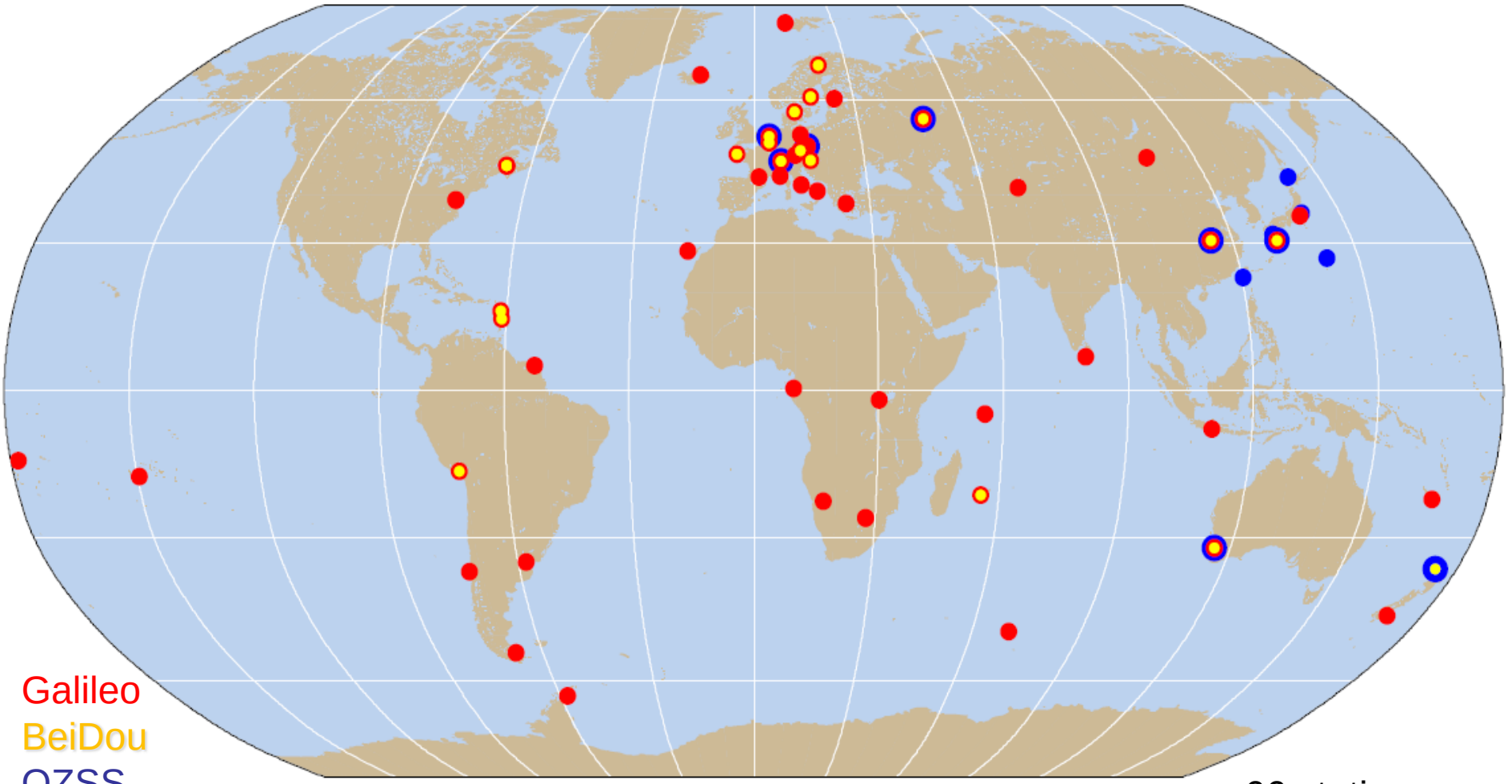
Multi-GNSS

- IGS is the International GNSS Service
  - Well established infrastructure, data and service for GPS (+ GLONASS)
  - IGS Strategic Plan foresees extension to all new GNSSs
- Ongoing deployment of new GNSSs with new signals and satellites
  - BeiDou, Galileo, QZSS, SBAS

Multi-GNSS Experiment (MGEX)

- Multi-GNSS Experiment (MGEX)
  - MGEX call-for-participation released mid-2011 (ongoing)
  - Steered by Multi-GNSS Working Group
- Continued evolution of products supporting multi-constellation, multi-frequency GNSS
- Some 10 contributing agencies
- About 66 stations worldwide, numerous real-time stations
- 6 major receiver types, 7 major antenna types
- Tracking of Galileo, BeiDou, QZSS
  - modernized GPS and GLONASS
- Data archives at CDDIS, IGN, BKG in RINEX 3.x
- Open data/product access

IGS MGEX Network

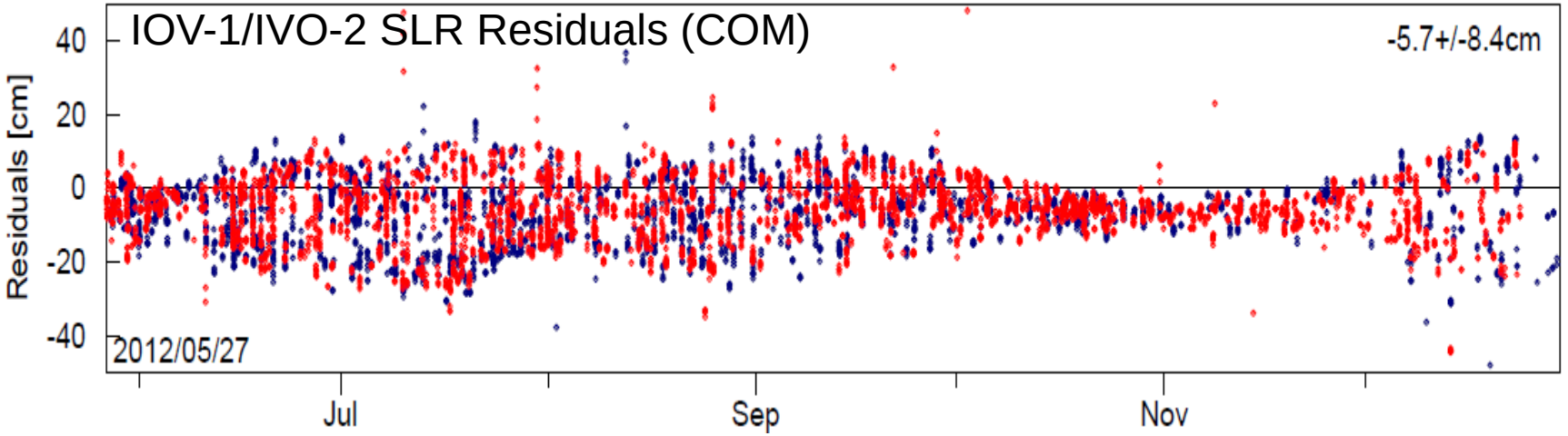


Galileo
BeiDou
QZSS

66 stations

IGS MGEX Products

- Currently Galileo and QZSS orbits and clocks
- Four contributing analysis centers
- Orbits at decimeter level accuracy
- Available at ftp://cddis.gsfc.nasa.gov/pub/gps/products/mgex/
- SLR residuals for Galileo IOV satellites:



Next Steps and Challenges

- Next steps:
  - Bias and ionosphere products
  - System characterization (ground and space segment)
  - Recruitment of additional analysis centers
  - Move towards a global multi-GNSS monitoring and assessment capability
- Challenges:
  - Resources (three new constellations, new products, improved performance)
  - Lack of tools (in particular: automated quality control)
  - Lack of information from system providers (except QZSS)

IGS Multi-GNSS Plan

High quality GPS/GLONASS network and products → High quality multi-GNSS network and products

2012 | 2013 | 2014 | 2015 | 2016 | 2017

MGEX

- Build-up and share multi-GNSS know-how
- Build-up network and provide access to multi-GNSS data
- Develop prototype multi-GNSS products
- Develop recommendations and standards
- Engage with receiver manufacturers and system providers
- RTS GPS PP

Transition

- Merge legacy and multi-GNSS networks
- Achieve interoperability of legacy and multi-GNSS products and services
- RTS GPS+ GLONASS

Multi-GNSS Pilot Service

- Incorporate BeiDou, Galileo, and QZSS into standard IGS processing
- Issue combined and quality controlled multi-GNSS IGS orbit, clock and iono products
- Regular multi-GNSS intersystem, interfrequency and intersignal bias estimation
- Link GNSS system times with IGS system time
- Embed new GNSSs into IGS/IAG reference frames
- RTS for multi-GNSS

Summary, Remarks

- IGS Key Projects support the transition to a full multi-GNSS Service with much reduced product latency:
  - Launch of Real-Time Service on April 1, 2013
  - Establishment of Multi-GNSS Experiment beginning of 2012
- IGS Real-Time Service:
  - High accuracy and redundancy
  - Transition to multi-GNSS RTS
- Multi-GNSS Experiment:
  - Targeting a multi-GNSS Pilot Service
  - Developing new products
- IGS welcomes strong support for these activities